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WHAT IS CLAIMED IS:

1. A plasma processing system comprising:
a plasma processing chamber;
5 a vacuum pump connected to the processing chamber;
a substrate support on which a substrate is processed within the processing chamber;
a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of the processing chamber;
10 a gas injector extending through the dielectric member such that a distal end of the gas injector is exposed within the processing chamber, the gas injector including a plurality of gas outlets supplying process gas at flow rates that are independently varied between at least some of the outlets into the processing chamber; and
15 an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.
2. The system of Claim 1, wherein the system is a high density plasma chemical vapor deposition system or a high density plasma etching system.
3. The system of Claim 1, wherein the RF energy source comprises an RF antenna and the gas injector injects the process gas toward a primary plasma generation zone in the chamber.
- 25 4. The system of Claim 1, wherein the gas outlets include a single on-axis outlet in an axial end surface of the gas injector and a plurality of off-axis outlets in a side surface of the gas injector, the on-axis outlet and the off-axis outlets being supplied process gas from a single gas supply via first and second gas lines, the gas lines

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including flow controllers which provide adjustable gas flow to the on-axis outlet independently of the off-axis outlets.

5 5. The system of Claim 1, wherein the gas outlets include a center gas
outlet extending in an axial direction perpendicular to the exposed surface of the
substrate and a plurality of angled gas outlets extending at an acute angle to the axial
direction, the center gas outlet receiving process gas supplied by a first gas line and the
angled gas outlets receiving process gas from a second gas line, the first and second gas
lines receiving process gas from the same gas supply.

10 6. The system of Claim 1, wherein the gas injector injects the process gas
at a subsonic, sonic, or supersonic velocity.

15 7. The system of Claim 1, wherein the gas injector includes a planar axial
end face having an on-axis outlet therein and a conical side surface having off-axis
outlets therein, the on-axis outlet receiving process gas from a central passage in the
injector and the off-axis outlets receiving process gas from an annular passage
surrounding the central passage.

20 8. The system of Claim 1, wherein the gas injector is removably mounted
in the dielectric window and supplies the process gas into a central region of the
chamber.

25 9. The system of Claim 1, wherein the gas injector includes at least one on-
axis outlet which injects process gas in an axial direction perpendicular to a plane
parallel to an exposed surface of the substrate and off-axis gas outlets which inject
process gas at an acute angle relative to the plane parallel to the exposed surface of the
substrate.

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10. The system of Claim 1, wherein the gas injector is removably mounted in the opening in the dielectric window and a vacuum seal is provided between the gas injector and the dielectric window.

5 11. The system of Claim 1, wherein the RF energy source comprises an RF antenna in the form of a planar or non-planar spiral coil and the gas injector injects the process gas toward a primary plasma generation zone in the chamber.

10 12. The system of Claim 1, wherein a single main gas supply is split into multiple gas supply lines to feed the gas outlets.

13. The system of Claim 1, wherein the ratio of gas flow through at least some of the gas outlets is independently varied using variable flow restriction devices.

15 14. The system of Claim 1, wherein the ratio of gas flow through at least some of the gas outlets is independently varied using a network of valves and throttling elements.

20 15 The system of Claim 1, wherein the gas injector is further provided with an electrically conducting shield which minimizes plasma ignition within gas passages located in the gas injector.

25 16. A method of plasma processing a substrate comprising:
placing a substrate on a substrate support in a processing chamber,
wherein an interior surface of a dielectric member forming a wall of the processing chamber faces the substrate support;
supplying process gas into the processing chamber from a gas injector extending through the dielectric member such that a distal end of the gas injector is

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exposed within the processing chamber, the gas injector including a plurality of gas outlets supplying process gas into the processing chamber;

controlling the flow rate of the process gas to at least one of the outlets independently of the flow rate of the process gas to at least one other of the outlets;

5 energizing the process gas into a plasma state by inductively coupling RF energy produced by the RF energy source through the dielectric member into the processing chamber, the process gas being plasma phase reacted with an exposed surface of the substrate.

10 17. The method of Claim 16, wherein the RF energy source comprises an RF antenna in the form of a planar or non-planar spiral coil and the gas injector injects some of the process gas through an on-axis outlet to a central zone in the chamber and through off-axis outlets to an annular zone surrounding the central zone.

15 18. The method of Claim 16, wherein at least some of the gas outlets inject the process gas in a direction other than directly towards the exposed surface of the substrate.

20 19. The method of Claim 16, wherein the gas injector extends below an inner surface of the dielectric window and the gas outlets inject the process gas in a plurality of directions.

25 20. The method of Claim 16, wherein the gas injector injects the process gas at a subsonic, sonic, or supersonic velocity.

21. The method of Claim 16, wherein individual substrates are consecutively processed in the processing chamber by depositing or etching a layer on each of the substrates.

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22. The method of Claim 16, wherein the gas injector extends into a central portion of the chamber and the gas outlets inject the process gas in multiple zones between the exposed surface of the substrate and the interior surface of the dielectric member.

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23. The method of Claim 16, wherein the gas outlets include a central on-axis gas outlet in the distal end of the gas injector and a plurality of off-axis gas outlets surrounding the on-axis gas outlet, the off-axis gas outlets injecting the process gas in a plurality of different directions.

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24. The method of Claim 16, comprising plasma etching an aluminum layer on the substrate by injecting a chlorine containing gas through the gas outlets, at least some of the gas outlets injecting the gas in a direction which is not perpendicular to the exposed surface of the substrate.

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25. The method of Claim 16, comprising plasma etching a polysilicon layer on the substrate by injecting a chlorine and/or bromine containing gas through a central gas outlet in an axial direction which is perpendicular to the exposed surface of the substrate and through a plurality of angled gas outlets surrounding the central outlet, the angled gas outlets injecting the gas in directions oriented at an angle of 10 to 90° to the axial direction.

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26. The method of Claim 16, comprising plasma etching a silicon oxide layer on the substrate by injecting a fluorine containing gas through a central gas outlet in an axial direction which is perpendicular to the exposed surface of the substrate and/or through a plurality of angled gas outlets surrounding the central outlet, the angled gas outlets injecting the gas in directions oriented at an angle of 10 to 90° to the axial direction.

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27. The method of Claim 16, comprising plasma etching a polysilicon layer on the substrate by injecting a chlorine and/or bromine containing gas through a central gas outlet in an axial direction which is perpendicular to the exposed surface of the substrate and through a plurality of angled gas outlets surrounding the central outlet, the angled gas outlets injecting the gas in directions oriented at an angle of 10 to 45° to the axial direction.

28. The method of Claim 16, comprising plasma etching a silicon oxide layer on the substrate by injecting a fluorine containing gas through a central gas outlet in an axial direction which is perpendicular to the exposed surface of the substrate and/or through a plurality of angled gas outlets surrounding the central outlet, the angled gas outlets injecting the gas in directions oriented at an angle of 10 to 45° to the axial direction.

29. The method of Claim 16, wherein a single main gas supply is split into multiple gas supply lines to feed the gas outlets.

30. The method of Claim 16, wherein the ratio of gas flow through at least some of the gas outlets is independently varied using variable flow restriction devices.

31. The method of Claim 16, wherein the ratio of gas flow through at least some of the gas outlets is independently varied using a network of valves and throttling elements.

32. The method of Claim 16, wherein the ratio of gas flow through at least some of the gas outlets is independently varied to etch a layer on the substrate so as to achieve uniformity in center-to-edge etching of the layer.

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33. The method of Claim 16, wherein the ratio of gas flow through at least some of the gas outlets is independently varied to deposit a layer on the substrate so as to achieve uniformity in center-to-edge deposition of the layer.

5 34. The method of Claim 16, wherein the gas injector is further provided with an electrically conductive shield which minimizes plasma ignition within gas passages located in the gas injector.

10 35. A gas injector for supplying process gas into a semiconductor processing chamber comprising:

an injector body which includes at least first and second gas inlets, at least first and second gas passages, and at least first and second gas outlets, the first gas passage being in fluid communication with the first inlet and first outlet, the second gas passage being in fluid communication with the second inlet and second outlet, the first and
15 second gas passages being discrete from each other so as to provide independently adjustable flow rates of gas through the first and second outlets.

20 36. The injector of claim 35, wherein the at least one first gas outlet comprises a single on-axis outlet in an axial end surface of the injector body and the at least one second gas outlet comprises a plurality of off-axis outlets in a side surface of the injector body.

25 37. The injector of claim 35, wherein the injector body includes a planar axial end face and a conical side surface, the at least one first gas outlet comprising an on-axis outlet in the axial end face and the at least one second gas outlet comprising off-axis outlets in the conical side surface, the on-axis outlet connected to a central passage in the injector and the off-axis outlets connected to an annular passage surrounding the central passage.

38. The injector of claim 35, further comprising an electrically conducting shield which minimizes plasma ignition within gas passages located in the gas injector.

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